PAN-PACIFIC ENTOMOLOGIST
71(3): 142–148, (1995)

ADULT FLIGHT DYNAMICS OF WALNUT HUSK FLY (DIPTERA: TEPHRITIDAE) IN THE WILLAMETTE VALLEY OF OREGON

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Abstract.—Seasonal flight of the walnut husk fly (WHF), *Rhagoletis completa* Cresson, was investigated using Pherocon AM traps in unsprayed trees, and commercial walnut orchards for a 4-year period (1990–1993). The adult emergence of WHF varied from year to year. The first flies in untreated trees were detected from July 1 through July 17; with an average of July 9. Seasonal peaks were observed between August 10 and September 4, and the last flies were trapped on September 11 through October 9. In commercial orchards, the first flies were trapped July 13 through August 5, seasonal peaks occurred around August 31 through September 9, and the last flies were trapped between September 14 through 30. Adult emergence occurred approximately two weeks later in commercial orchards. Only one generation per year was recorded. Dissections of females indicated that under field conditions, WHF was capable of egg laying 7 days after emergence, and females with mature eggs were found throughout the walnut growing season.

Key Words.—Insecta, *Rhagoletis completa,* walnut husk fly, flight activity, seasonal flight

The walnut husk fly (WHF), *Rhagoletis completa* Cresson, is a pest of walnuts throughout western North America. Like other tephritids, WHF flight activity is dependent on the availability of food, shelter and oviposition sites. Gibson & Kearby (1978) in Missouri and Riedl & Hoying (1980) in California studied WHF flight activity using Pherocon AM traps and reported that WHF was active from July through October. Other *Rhagoletis* sp. are reported to be active during this time period, although slight differences were found due to host type and environmental conditions (Frick 1952; Oatman 1964; Dean & Chapman 1973; AliNiazee 1976, 1978; Trottier et al. 1975; AliNiazee & Westcott 1987; Jones et al. 1989, 1991). Although WHF is a serious walnut pest in the Pacific Northwest, few studies have been conducted on its biology in this region. This study investigated the seasonal flight pattern of WHF from western Oregon, analyzed seasonal maturity of ovipositing females in the field, and determined the impact of environmental conditions such as temperature and rainfall on the flight pattern.

MATERIALS AND METHODS

Adult Flight Dynamics in Unsprayed Trees.—Unsprayed, mature backyard 'Franquette' walnut trees with a history of high WHF infestation were selected for this study. Commercially available standard Pherocon AM yellow sticky traps (Trece, Salinas, Calif.) without additional ammonium carbonate lure, were hung at a height of 2 m above the ground on bearing trees (Anonymous 1982) at the four compass directions to trap flies. A total of 5 different sites were used and a minimum of two traps placed at each site. Traps were hung at the outside of the tree canopy, and small branches and leaves were cleared away to increase visibility and prevent leaves from touching the trap surfaces. From mid June until the end

Table 1. Four year pattern of adult catches of *Rhagoletis completa* in Pherocon AM traps in unsprayed walnut trees, Willamette Valley, Oregon.

Year	Date flies caught			First mature female	Last immature female	Total flight duration (days)	Average no. of flies/trap/season
	First	Peak	Last				
1990	7/11	8/27	10/1	7/23	9/10	82	456
1991	7/17	9/4	10/9	7/29	9/16	86	488
1992	7/1	8/10	9/11	7/13	8/17	75	451
1993	7/9	8/30	10/1	7/23	—	77	690
Mean	7/9	8/19	9/28	7/22	9/4	80	521

of October, traps were replaced every 4 weeks (AliNiazee & Fisher 1985). The trap catches were monitored three times a week, and each time a count was taken the traps were cleaned. The flies were removed from traps, sexed (Moffitt 1958), washed in kerosene oil and females were stored in a 70% ethanol-glycerol solution by date for ovarian development studies.

Adult Flight Dynamics in Commercial Walnut Orchards.—Two commercial walnut orchards in Junction City, Oregon were selected for this study. Orchard No. 1 was a 3 hectare planting of 'Franquette' which had been sprayed annually for WHF control. Orchard No. 2 was a 5 hectare block of mixed varieties, 'Franquette,' 'Manregian,' 'Mayette,' 'Spurgeon,' and 'Hartley,' which was not treated for WHF or other pests during the study period. Irrigation, nitrogen fertilizer use and other cultural practices including sheep grazing were practiced in both orchards. Two Pherocon AM traps were evenly spaced on south side of two trees 2 m above ground in each orchard. The trap catch was monitored weekly during 1991 and 1992 seasons. Trapped flies were sexed and counted. The females removed from the traps were washed in kerosene oil and stored in 70% ethanol-glycerol by date for laboratory dissections.

Female Ovarian Development Under Field Conditions.—The females collected from Pherocon AM traps were dissected in the laboratory to determine presence of eggs and egg development. Egg development in the ovaries was used to group the flies into two categories: undeveloped (mature oocytes absent), and developed (with varying degree of ovarian development but a minimum of full sized terminal oocytes). The latter category included females capable of laying eggs.

Results and Discussion

Adult Flight Dynamics in Unsprayed Trees.—Initial trap catch in unsprayed trees occurred on Jul 11, 17, 1 and 9, respectively for 1990, 1991, 1992, and 1993 study years (Table 1). The peak catches for these same years were Aug 27, Sep 4, Aug 10 and Aug 30. Fly capture terminated on Oct 1, 9, Sep 11 and Sep 24, respectively for 1990 through 1993. The total number of days flies were trapped varied from 75 in 1992 to 86 in 1991 (Table 1). A sex ratio of close to 1:1 was noticed during the entire study period. In general females outnumbered males during the early season with males more abundant after mid-season (Figure 1).

The average date of first fly catch for the 4-year study period was Jul 9, the peak Aug 19, and last catch Sep 28. There was a remarkable degree of consistency in the time of first fly catch during the study period (mean Jul 9 $\pm$ 7 SD day).

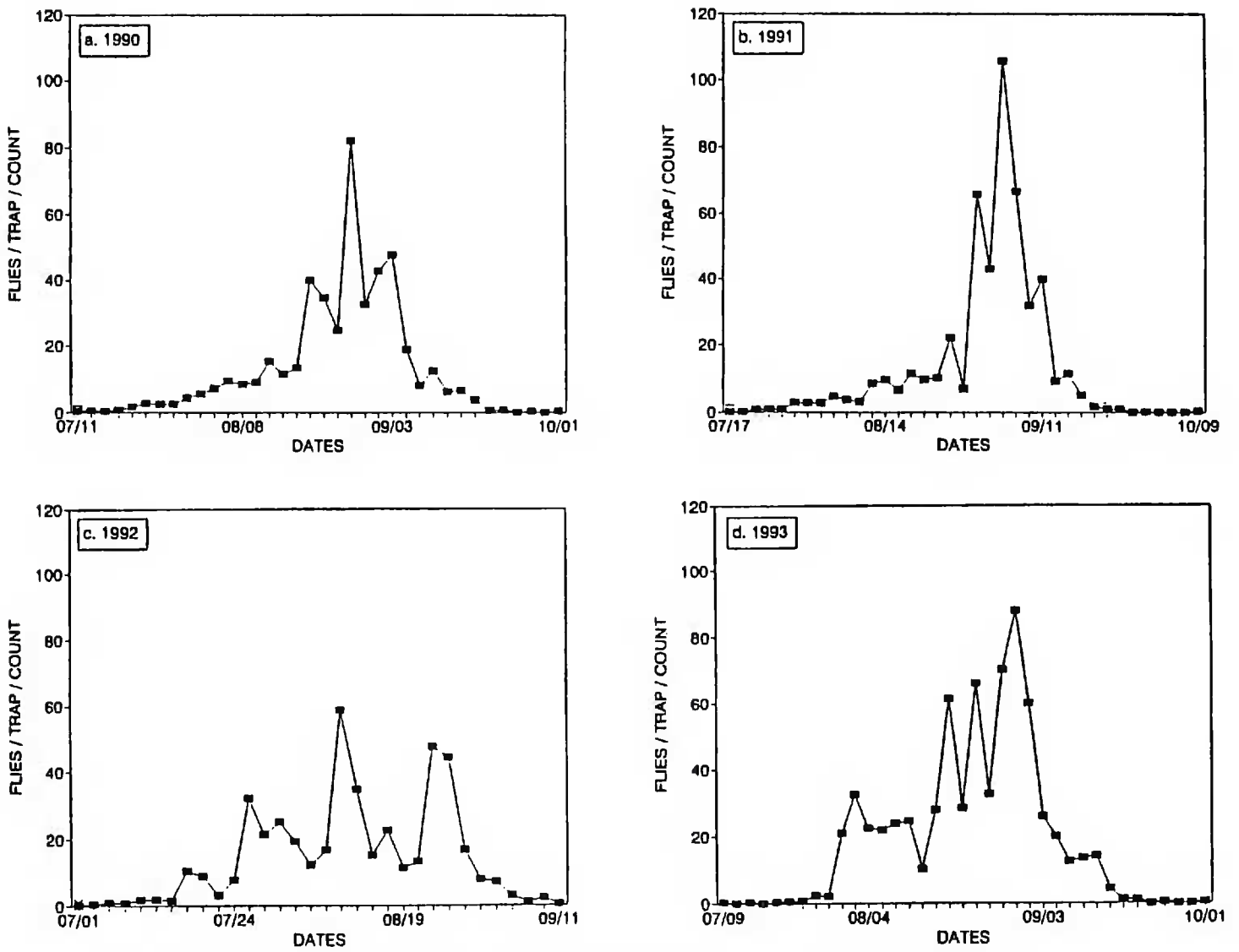

Figure 1. Seasonal patterns of flight activity of *Rhagoletis completa* in the Willamette Valley of Oregon for a four year period, 1990–93 (unsprayed walnut trees).

The number of flies trapped varied over the years but consistently high (range 451–690/trap) indicating the presence of a high adult population in the field.

Effect of Quadrants on Trap Catches.—There were no significant differences in trap catches among quadrants during any year except for the capture of first fly and last fly. In 1990, the first fly was captured on Jul 11 in the south quadrant, in 1991, on Jul 17 in the south quadrant, in 1992, on Jul 1 in the west quadrant, and in 1993 on Jul 9 in the east quadrant (Figure 2). The last flies of the season were trapped on 11 Sep 1990 in north quadrant, 30 Oct 1991 in the south and the west quadrants, 11 Sep 1992 in north and south quadrants, and Sep 24 in the west quadrant (Figure 2).

Table 2. Seasonal pattern of *Rhagoletis completa* catches in Pherocon AM traps in commercial walnut orchards.

Year	Date flies caught			First mature female	Last immature female	Total flight duration (days)	Average no. of flies/trap/season
	First	Peak	Last				
Orchard no. 1							
1991	8/05	9/09	9/23	8/12	8/26	49	111
1992	7/13	8/31	9/14	7/27	8/24	63	342
Orchard no. 2							
1991	8/05	9/02	9/30	8/19	9/02	56	207
1992	7/13	8/31	9/14	7/27	8/17	63	305

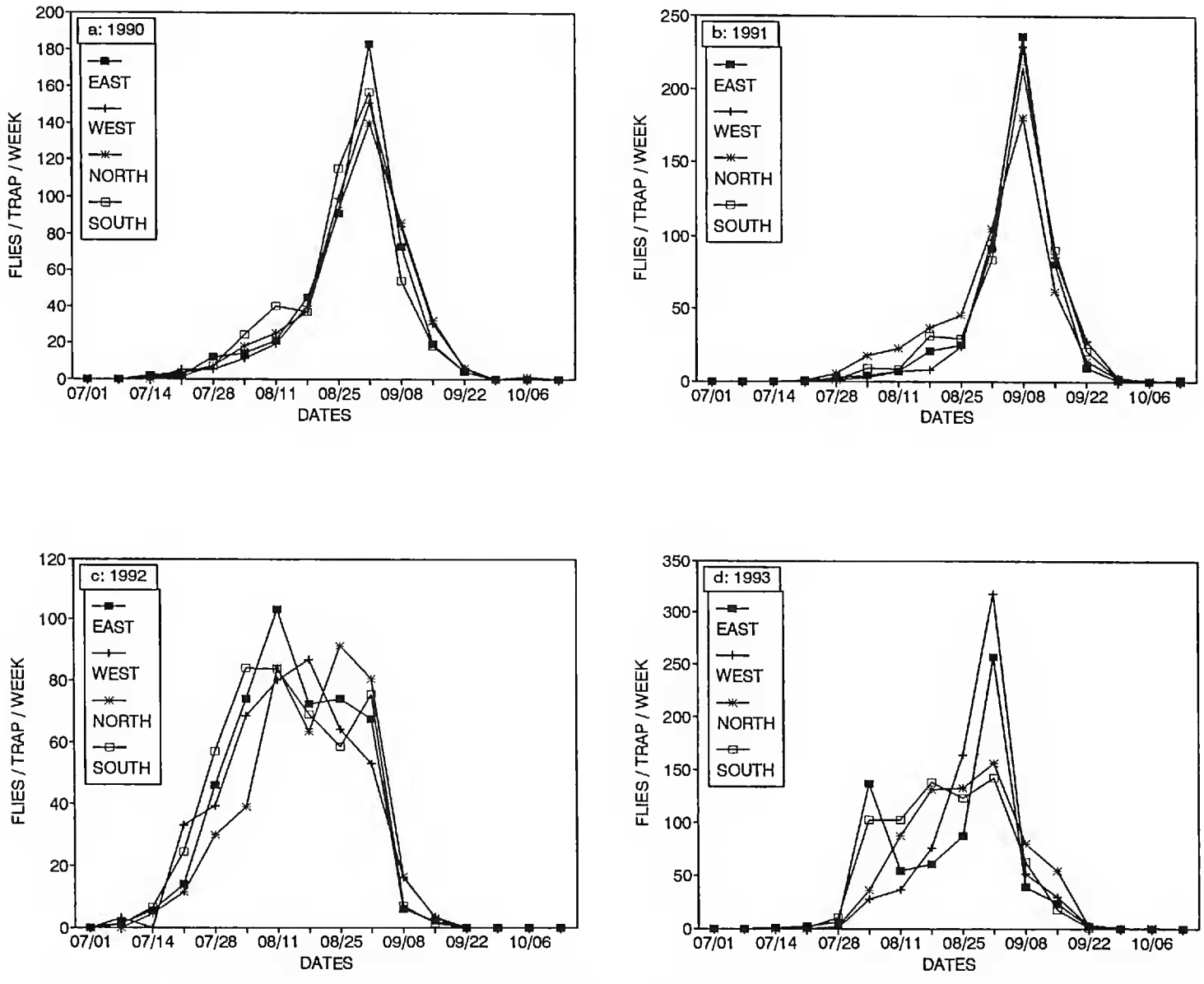

Figure 2. Quadrant-wise seasonal patterns of flight activity of *R. completa* under unsprayed walnut trees.

In general, the earliest activity was seen in the south and east sides, with the north side last. Fly catch varied by quadrant from 23 to 26% of total flies captured suggesting an even distribution of flies throughout the trees. Similarly, Oatman (1964) found no significant difference in *Rhagoletis pomonella* (Walsh), activity among tree quadrants in Wisconsin.

Adult Flight Dynamics in Commercial Walnut Orchards.—During 1991, in commercial walnut orchards, the first fly was trapped on Aug 5 (Figure 3), fly catches generally increased with a seasonal peak on Sep 9 (Orchard 1) and Sep 2 (Orchard 2), and catches terminated on Sep 23 (Orchard 1) and Sep 30 (Orchard 2). A synthetic pyrethroid insecticide (Asana) was applied on Aug 26 in Orchard 1 while Orchard 2 was left untreated. Total flight activity in Orchard 1 lasted for 49 days and in Orchard 2 for 56 days.

During 1992, the fly activity was earlier than 1991; the first fly was trapped on Jul 13 in both orchards, with a seasonal peak on Aug 31, and no flies were caught after Sep 14 (Figure 3). The Orchard 1 was again sprayed with Asana on Aug 26, while Orchard 2 was left untreated. The total flight period during 1992 was 63 days in both orchards and the sex ratio was approximately 1:1.

A comparison of flight patterns from commercial orchards and unsprayed trees showed a 15 day difference in emergence in 1992, and 19 day in 1991 with

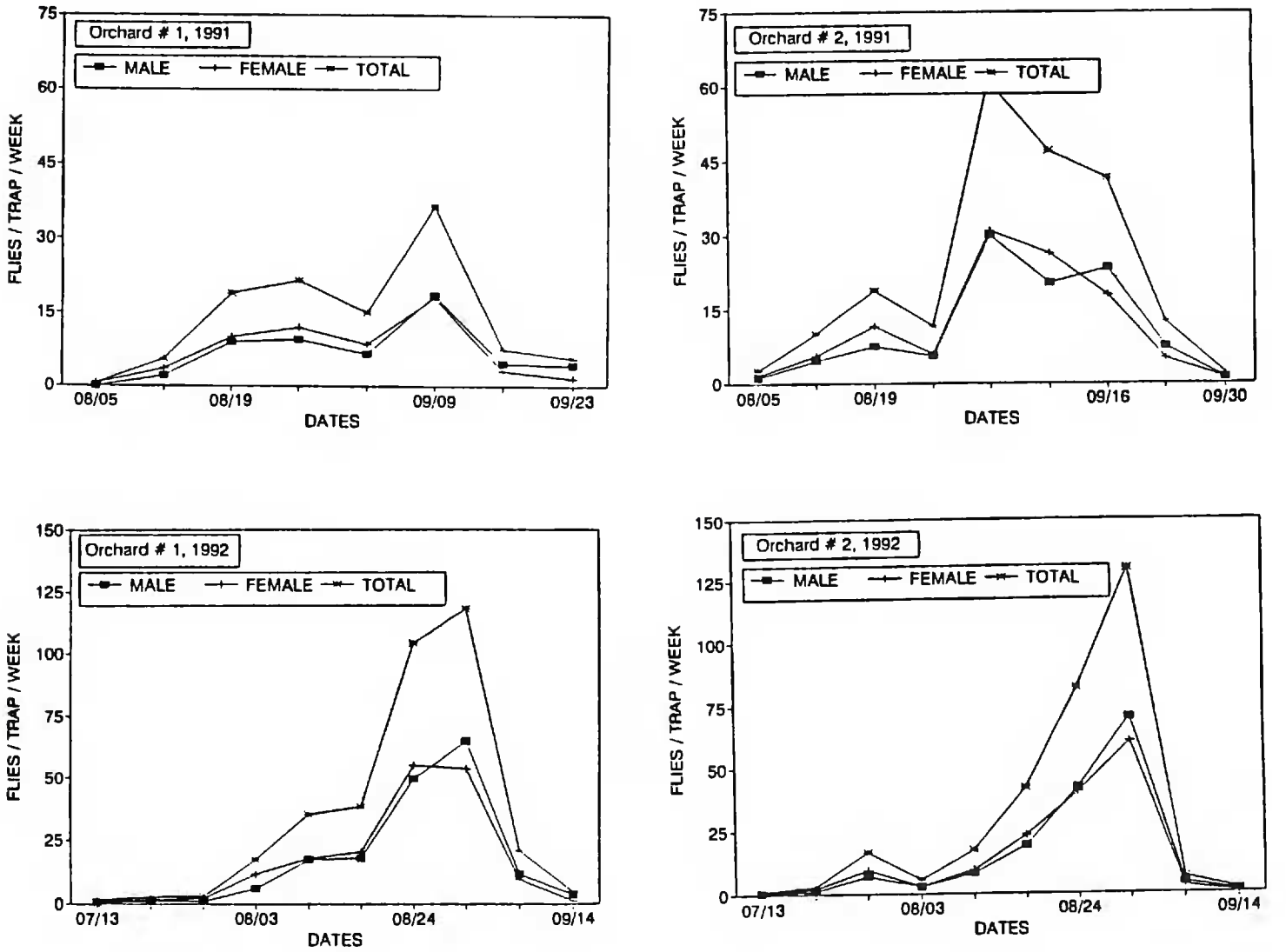

Figure 3. Seasonal patterns of flight activity of *R. completa* in commercial walnut orchards, 1991–92.

emergence occurring earlier in the unsprayed trees. Inter-population differences in emergence of *Rhagoletis* sp. have been reported before. Jones et al. (1989) reported that *R. pomonella* populations emerged 5 weeks apart in different regions in Utah. AliNiazee & Fisher (1985) reported that WHF emergence varied among orchards within a given area and among different locations within an orchard. Large variations in first emergence of *R. pomonella* among adjacent cages in the same orchard were recorded in New York (Glass 1960, Dean & Chapman 1973). Physical factors such as the depth at which the pupae overwinter, slope, soil type, soil cover, planting density, and genetic factors are probably responsible for variation of adult emergence. Such variation may be an evolutionary adaptation because food and mates may not be present throughout the adult life span.

The time of capture of WHF in ground emergence cages during 1991, 1992 and 1993 coincided with the time of their capture in aerial traps. This suggests a close temporal relationship between first fly emergence in ground emergence cages (Kasana & AliNiazee in press) and the first fly catch in Pherocon AM traps.

Daily rainfall and temperature fluctuation were found to be unrelated to flight pattern of WHF. It appears that unlike *R. pomonella* for which rainfall has been shown to accelerate fly emergence (Brittain & Good 1917, Phipps & Dirks 1933, Jones et al. 1989), the WHF emergence does not increase after rainfall, although further research along these lines is required. None of the studied orchards were irrigated.

The first sexually mature females were trapped on 23 Jul 1990, 29 Jul 1991, 13 Jul 1992, and 23 Jul 1993. The peak activity of sexually mature females was on 27 Aug 1990, 5 Sep 1991, and 10 Aug 1992. The last sexually mature females were trapped on 10 Sep 1990, 16 Sep 1991, and 17 Aug 1992. This corresponds well with the ovipositional activity in the field. Our data indicate that aerial traps were effective in trapping both sexually mature and immature flies. However, as season progressed, the capture of mature females increased.

Sexually immature flies represented 10.8% of the total capture in 1990; 8.2% in 1991 and 20% in 1992 indicating that only a small proportion (13–14%) of trapped females were sexually immature, and a majority were mature flies, ovipositing or ready to oviposit.

In commercial walnut Orchard 1, the first sexually mature female was caught on 12 Aug 1991, and 27 Jul 1992. In Orchard 2, the first sexually mature female fly was trapped on 19 Aug 1991, and 27 Jul 1992. The last immature female was trapped in Orchard 1 on 26 Aug 1991, 24 Aug 1992, and in Orchard 2, on 2 Sep 1991, 17 Aug 1992. This indicates little difference between the untreated trees and commercial orchards in the sexual maturity pattern of flies.

In Orchard 1, the percentage of sexually immature females trapped ranged from 19.3% in 1991 to 10% in 1992. In general, the number of sexually immature females was 14%. In Orchard 2, 16.5% of the females trapped were sexually immature in 1991 and only 9% in 1992.

The appearance of mature fruit flies in the field is an important event that has a direct bearing on pest control decisions. Once it is known that the females have attained sexual maturity, the oviposition event can be monitored, and accurate curative measures can be taken. There was no indication of a second generation of WHF in this study.

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